HIGH VOLTAGE POWER SUPPLY INSTRUCTION MANUAL

Model: BRC-15-1111R-STD-J37

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Revision: A

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Universal Voltronics

HIGH VOLTAGE POWER SUPPLY INSTRUCTION MANUAL

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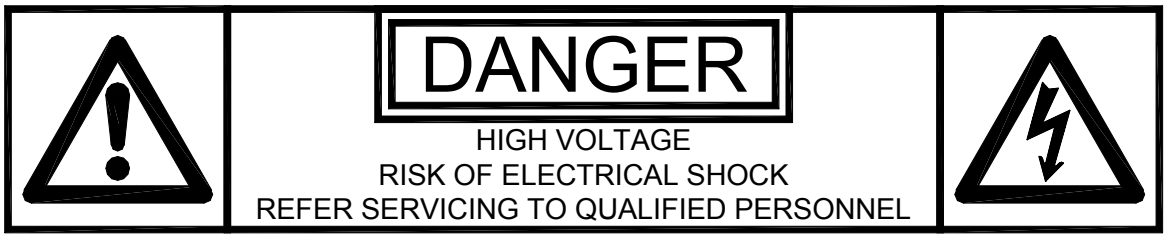
1. INTRODUCTION

This high voltage power supply incorporates the latest in high frequency, high power switching technology. Each unit is neatly packaged in a single, rack-mountable chassis with approximate dimensions of 10.5" high X 19" wide (maximum) X 21" deep (approximately 2 additional inches are required behind the chassis for connections).

Operation of the power supply can be accomplished locally via the front panel controls and/or remotely via the rear panel User Interface connector J4. Certain commands or signals are operative in both modes. For example, the local HV OFF pushbutton switch is operative in both Local and Remote modes. Refer to Section 5, "User Interface", for details.

The polarity of the output is adjustable, however each unit is shipped from the factory in negative output mode. The output polarity can be altered by changing the position of the output polarity plate.

2. WARNINGS



This power supply operates at a high enough voltage and possesses sufficient stored energy to be capable of killing a human.

DO NOT TAKE SAFETY FOR GRANTED!

Pay strict attention to the safety information and warnings in this manual.

This power supply produces extremely high voltages. DO NOT attempt to adjust any load connection with high voltage on. DO NOT attempt to open the power supply enclosure unless the manual has been thoroughly reviewed and the internal layout is understood. Never reach into the enclosure unless the power has been disconnected and the output is fully discharged. Be certain of safety ground connections.

Assuming that high voltage is always ON is the best way to avoid hazard to personnel. Always shut off the supply circuit breaker(s) and follow an appropriate grounding procedure to discharge the output before touching any exposed connections.

DO NOT rely on the power supply's instrumentation or controls to determine that the output is safely discharged. The sensors are driven by amplifiers, which are powered by an internal low voltage power supply, as are the indicator LEDs. There may be dangerous voltages present on the output, even if the unit appears "dead".

If not manually discharged, the output may remain charged long after power is disconnected!

DO NOT allow anyone who has not reviewed the manual to perform any part of the installation process or to attempt servicing of the power supply. Any questions must be brought to the attention of the manufacturer.

DO NOT obstruct the cooling inlets or outlets. Overheating can result, which may damage the power supply.

3. UNPACKING

Remove the unit from its carton, but do not discard the packing materials; retain the packing materials and carton in case the unit needs to be returned.

Inspect the unit for dents or other damage, which may have occurred during shipping. In the unusual event that shipment damage has occurred, contact the transportation company and the manufacturer immediately.

If additional materials have been enclosed in the shipping crate (such as cables etc.), inspect them as well. Put them aside and DO NOT proceed until this instruction manual has been thoroughly reviewed.

4. INSTALLATION

Symbol Definitions

Protective Conductor Terminal
Indicates where to connect safety ground conductor from AC line source.

Caution: Risk of Electric Shock
Indicates that high voltages, capable of causing injury, are present on the output connector.

Caution: Refer to Manual for Further Instructions
Directs user to manual for further detailed instructions on installation and operation. Refer to Section 2 of this manual.

Input Voltage Selection

Before the BRC power supply may be installed, it is critical that the AC line voltage being connected to the unit fits within the specifications below:

208VAC ±10% (187-229 VAC), 3-phase

The power supply does not require an electrical neutral. The unit is not sensitive to phase rotation. Double check your power wiring before proceeding with the installation.

CAUTION

Chassis supports must not block air passages located on the unit's side panels. A fan located on the left side panel pulls air in through a heatsink located on the right side panel.

1. Turn OFF the front panel circuit breaker.

2. Connect the ground stud on the rear panel of the chassis to a suitable building or system ground, and to the low end of the output load(s). Use a 0.5 inch (~1.3 cm) wide metal earthling braid or #6 AWG UL1015 insulated stranded wire with properly crimped ring terminals where required. Heavier conductors may be used. The ground stud on the rear panel should be the common point of all ground connections.

3. Terminate the high voltage output cable to the high end of the load. Make sure it is tightly fastened.

4. It is good practice to keep the high voltage (HV) cable away from sharp objects, machinery, and high traffic areas. This will minimize the possibility of damage to the cable.

5. Ensure the Local/Remote switch on the rear panel is set to the proper mode of operation, either local or remote, as described in Section 5.

6. Connect remote control circuitry (if used) to the rear panel connector, J4, as described in Section 5.

7. With the breaker in the OFF position and the building power OFF, connect AC power lines to the unit. It is very important to use 600V (UL1015) insulated stranded wire of sufficient gauge (#6 AWG or greater) to handle the full load line current. Strip about 0.4 inch (~1 cm) of insulation from the wires before inserting them into the terminal block.

   Phase sequence is not critical on this three phase switching power supply.

8. When all of the connections have been double checked, apply AC power from the source circuit breaker box and turn the front panel circuit breaker ON. The unit is now ready for high voltage operation.

5. USER INTERFACE

Operation of the User (Remote) Interface is essentially equivalent to the local front panel controls. Each unit has been shipped from the factory in Remote mode. To change to Local mode operation, use the Local/Remote switch located on the rear panel. See Figure 1 for an illustration of the Local/Remote switch and the Regulator connector located on the rear panel.

Functions that are underlined are operational in both Local and Remote modes. In addition, please note that the local HV OFF switch is operational in both Local and Remote modes for safety reasons.

Pin Assignments- J4 (HV Regulator 9120010)

Pin # Function (Input or Output)

1. Voltage Reference (Input):

This high impedance input should be connected to a low impedance voltage source (less than or equal to 1k ohms). A typical input would be the analog output of a computer interface. Zero volts applied here is equal to a zero volt HV output, and +10V is equal to a -15.0kV HV output (0 to +10V = 0 to -15.0kV).

2. Common Pin for References (Input):

Connect to the return of the analog signal (or other voltage source) applied to pin 1.

3. Current Reference (Input):

This high impedance input should be connected to a low impedance voltage source (less than or equal to 1k ohms). A typical input would be the analog output of a computer interface. Zero volts applied here is equal to a zero ampere HV output, and +10V is equal to a -1.111A HV output (0 to +10V = 0 to -1.111A).

4. Analog Voltage Monitor (Output):

This low impedance output should be connected to a high impedance load. A typical load would be a voltmeter or the analog input of a computer interface. A micrometer or millimeter, in series with an appropriate resistor, will function well. It is best if the resistor is adjustable so that the meter calibration may be trimmed. Zero to +10V on this pin represents zero to -15.0kV HV output (0 to +10V = 0 to -15.0kV). The source impedance for this signal is 1k ohm.

5. Common Pin for Analog Monitors (Output):

Connect to negative terminal of meters or return of other measurement instrument applied to pins 4 and 6.

6. Analog Current Monitor (Output):

This low impedance output should be connected to a high impedance load. A typical load would be a voltmeter or the analog input of a computer interface. A micrometer or millimeter, in series with an appropriate resistor, will function well. It is best if the resistor is adjustable so that the meter calibration may be trimmed. Zero to +10V on this pin represents zero to -1.111A HV output (0 to +10V = 0 to -1.111A). The source impedance for this signal is 1k ohm.

7, 8. High Voltage OFF Control (Input):
Connect to a normally closed (NC) set of isolated ("voltage free" or "dry") switch contacts. Operation of these contacts must be momentary (i.e. the contacts stay closed until the switch is operated, at which time they open briefly, and the contacts automatically return to the closed state after an operation).

9, 10. External Interlock (Input):
Short these pins together to complete interlock loop.

11, 12. High Voltage ON Control (Input):
Connect to a normally open (NO) set of isolated switch contacts. Operation of these contacts should be momentary, but an alternate action switch is acceptable.

13. Remote HV ON Monitor (Output):
This signal is +5VDC when HV is ON and is +0VDC when HV is OFF.

14. Common Pin for High Voltage ON Control and Inhibit Command (Input):
Connect to return for Remote HV ON Monitor and Inhibit Command signals.

15. Inhibit Command (Input):
This input is used to prevent high voltage from being turned on in any mode of operation. By maintaining +5VDC on this pin (TTL high state), high voltage is prevented from being turned on by the front panel pushbutton or the User Interface, and will terminate high voltage if in the ON state.

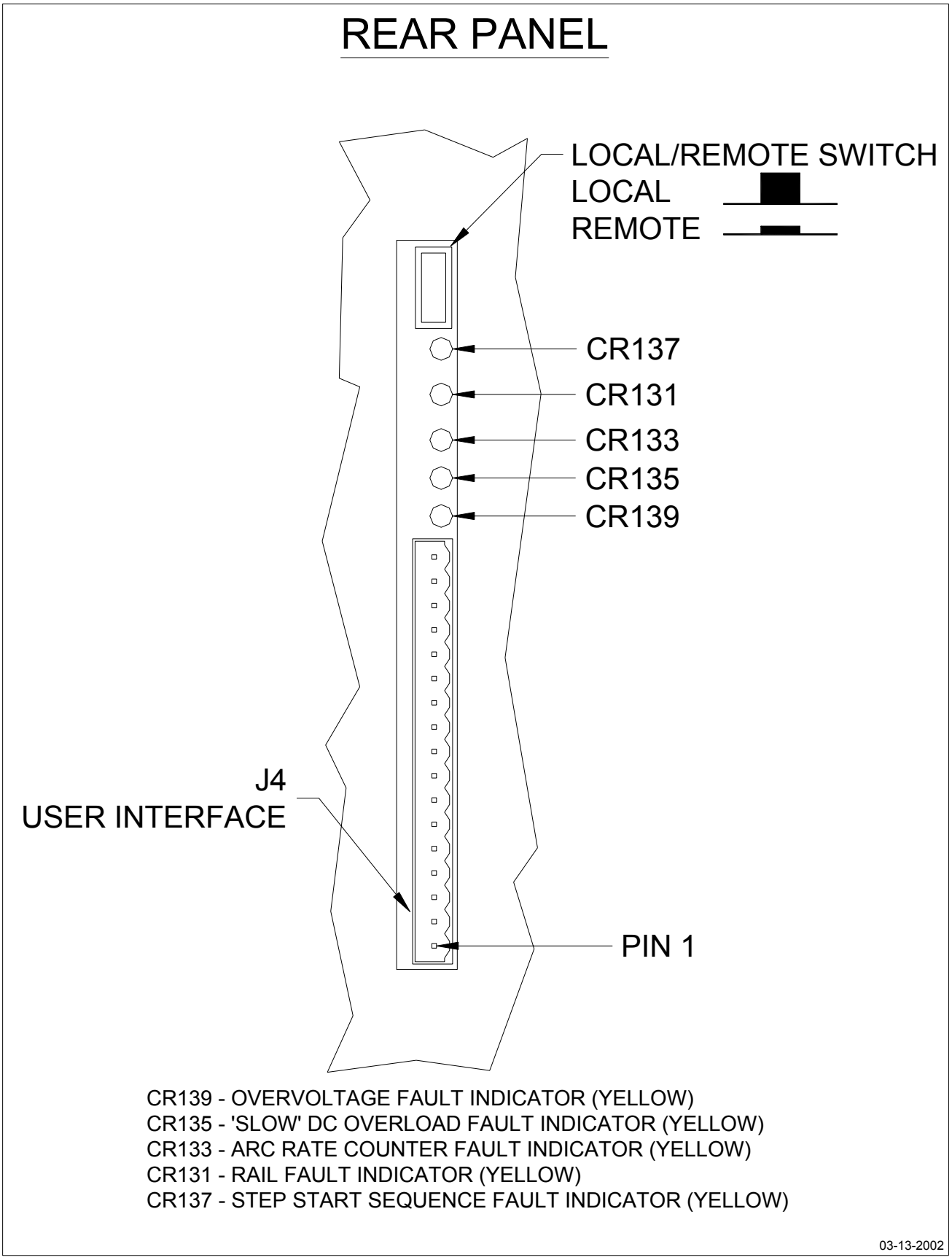


Figure 1 – User Interface

6. THEORY OF OPERATION

The power supply consists of several sections shown in the following simplified diagram:

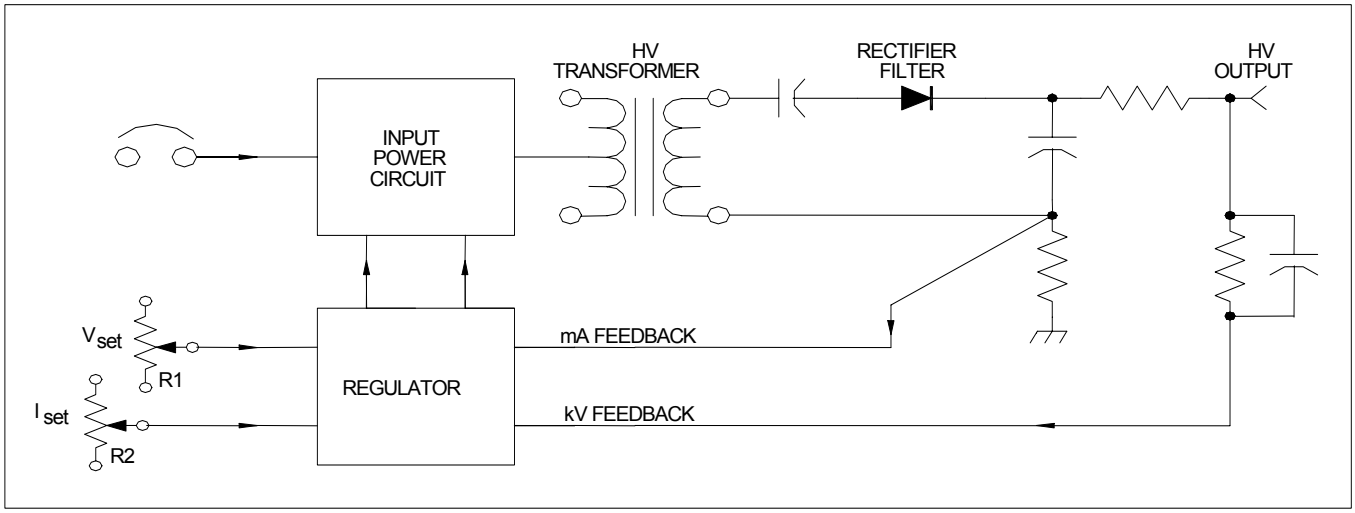


Figure 2 – Power Supply Simplified Diagram

NOTE: Vset and Iset above may be produced by either the front panel potentiometers or voltage signals from an external source, depending on whether Local or Remote mode is being used.

6.1 Regulator 9120010

The regulator circuit receives the two reference voltages (0 - 10V), as set by the remote references or by the front panel voltage and current pots, R1 and R2, respectively. See Figure 2. These reference voltages feed the KV error amplifier and mA error amplifier. The objective of each error amplifier is to make the feedback signal equal to the reference signal. The pulse width modulator chip generates the main switching frequency (approximately 22kHz).

6.2 Power Card 853189539P

AC power is connected to a three phase bridge rectifier circuit. See Figure 3. The rectifiers power a raw capacitive filter. The inverter switches, in a full bridge configuration, alternate the high voltage transformer primary winding between the rail voltages established by the raw supply capacitors, producing a bipolar square wave signal on the primary winding.

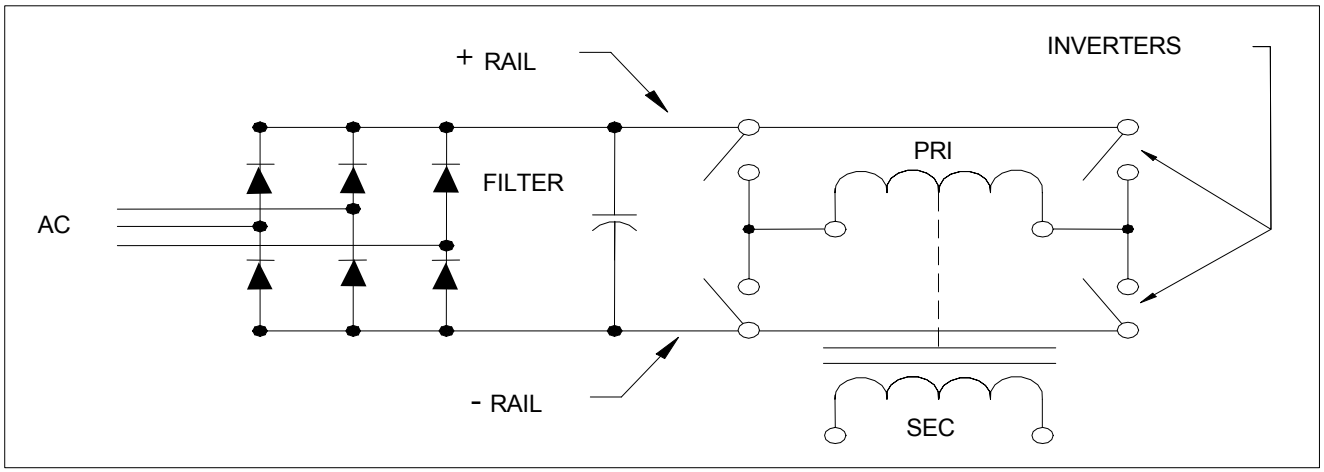


Figure 3 – Power Inverter Simplified Diagram

The inverter switches are IGBTs that are gated 'ON' for an interval established by the pulse width modulator chip on the Regulator card. At power turn-on, the raw capacitor bank is charged through rectifier CR12 and current limited by R42 and R43. When the initial charge period is complete, relay K1 is energized, connecting the rail capacitors to the low impedance three-phase line.

The inverter IGBTs do not operate until the raw capacitors are charged, K1 is energized, and the 'HV ON' pushbutton is depressed. The IGBT gate signal originates on the Regulator board as varying width pulses at a fixed frequency. The frequency is determined by R219 and C133 on the Regulator board.

7. HIGH VOLTAGE ON

Once the installation is complete, the power supply is ready to be energized. Turn on the system power at the source circuit breaker box. To activate the control electronics, switch the front panel breaker to the ON position. The 'Power On' indicator will be illuminated.

Local Mode

High voltage can be activated if all interlocks and faults are clear. To enable high voltage, press the 'HV ON' pushbutton. The white 'HV ON' light will illuminate indicating that there is high voltage on the output. To turn the supply off, press the 'HV OFF' pushbutton. This will disable high voltage and clear any faults.

The 'kV Adjust' knob and the 'A Adjust' knob must both be above zero to allow the power supply to produce any output voltage or current. 3½ digit panel meters for output voltage and current have been provided on the front panel. They facilitate easy interpretation of the output values at a glance. LEDs below the front panel LCD displays indicate the mode of control, voltage regulation or current regulation.

Remote Mode

If all interlocks and faults are clear, the User Interface can now be used to activate and control the high voltage output. Refer to Section 5 for User Interface control details.

8. SPECIFICATION

15.0kV 1.111A SWITCH MODE POWER SUPPLY

8.1 INPUT

Voltage	208V ±10% (187-229V)
Phases:	Three
Frequency:	50/60 Hertz
Current:	65A max.

8.2 OUTPUT

Voltage:	0 to -15.0kV DC
Current:	0 to -1.111A DC
Polarity:	Changeable (shipped as Negative)
Regulation:	± 0.1% (± 15.0V)
Ripple:	0.5% rms (75V rms) max.

8.3 LED INDICATORS (FRONT PANEL)

Power On	Indicates AC power is active
Fault	Indicates a power supply fault is present
Positive	Output polarity is positive
Negative	Output polarity is negative
Kilovolts	Indicates when unit is in voltage regulation mode
Amperes	Indicates when unit is in current regulation mode

8.4 LCD INDICATORS

Output Voltage Meter, 3.5 Digits, 15.0kV
Output Current Meter, 3.5 Digits, 1.111A

8.5 LOCAL CONTROL

Main Circuit Breaker
High Voltage ON pushbutton
High Voltage OFF pushbutton
kV Adjust knob
A Adjust knob

8.6 FEATURES

Oil-free design
High frequency switching technology

8.6 REMOTE CONTROL

Reference Inputs	Voltage:	0 to +10V = 0 to -15.0kV DC
	Current:	0 to +10V = 0 to -1.111A DC
Monitor Outputs	Voltage:	0 to -15.0kV DC = 0 to +10V DC
	Current:	0 to -1.111A DC = 0 to +10V DC
Digital Signal Inputs	HV ON:	Momentary contact closure
	HV OFF:	Momentary contact opening
Digital Signal Outputs	HV On:	TTL High

8.7 MECHANICAL

Panel	19” wide x 7” high max.
Chassis	21” deep (not including approx. 2” for connections)
Weight	100 lbs (including packaging)
HV Output	Fixed, rear panel
Control Interface	Phoenix MSTB-1.5/17-ST-508(or equivalent) connector, rear panel (J4)
Power Input	3-position terminal strip, rear panel
Ground Connection	¼ – 20 stud, rear panel

8.8 FUSING

Regulator 9120010 (F1)	Bussmann GDC-100mA (250VAC, 0.1A, time delay)
Regulator 9120010 (F3)	Bussmann GDC-500mA (250VAC, 0.5A, time delay)
Inverter 853189539P (F1,2)	Bussmann GDB-4A (250AC, 4A, fast acting)

9. CIRCUIT BOARD ADJUSTMENTS

Although each power supply is fully tested and calibrated prior to shipment, there are circuit boards in the unit that may require adjustment at some time during the life of the power supply. These boards are the Regulator board (9120010) and Front Panel board (9120021).

Before attempting to make any adjustments inside the power supply chassis, please be sure that the consequences of such an adjustment are completely understood.

Do not attempt to make any adjustment unless you fully understand the function of each potentiometer. These adjustments are preset by the manufacturer and should not be disturbed unless you are experiencing difficulties.

Refer to Figures 4 and 5 for the exact locations of adjustment potentiometers on the circuit boards (PWAs) listed above. Also refer to the list on the following page, which will describe the function of each potentiometer in detail.

For a detailed description of adjustment procedures, see the Acceptance Test Procedure called out in Section 13.

Potentiometer Function Descriptions

Front Panel PWA 9120021:	R6	Front panel voltmeter calibration.
	R7	Front panel ammeter calibration.
	R9	Shutdown timer one-shot period: sets length of time unit will stay in the shutdown state after an arc or similar event.
Regulator PWA 9120010:	R1	High voltage feedback divider AC compensation: adjusts AC gain of feedback divider.
	R103	Divider current compensation: removes the loading effect (current drain) of the internal feedback divider which would otherwise cause an error in the current feedback signal.
	R25	kV Cal: calibrates the ratio between the voltage reference and the actual output voltage when the unit is in voltage regulation mode.
	R197	mA Cal: calibrates the ratio between the current reference and the actual output current when the unit is in current regulation mode.
	R83	kV Mon Cal: calibrates the ratio between the actual output voltage and the monitor signal, which is fed to both the User Interface J4 connector on the rear panel and to the front panel voltage meter.
	R181	mA Mon Cal: calibrates the ratio between the actual output current and the monitor signal, which is fed to both the User Interface J4 connector on the rear panel and to the front panel current meter.

R41 Iavg OL Adjust: sets the sensitivity of the HV transformer's average primary current limit circuit. This protects the power inverter from large values of average current over a period of many inverter cycles. This circuit does not protect against high peaks of instantaneous current.

R149 Counter Adjust: sets the sensitivity of the arc counter circuitry which shuts off high voltage if too many arcs or rollbacks occur in a given period of time. It also functions as an arc rate circuit, since a rapid succession of arcs is more apt to trip the circuit than the same number of arcs spread out over a longer period of time.

R165 Rail Fault Adjust: sets the trip point of a circuit which is sensitive to excessive current in the power inverter. This type of fault could indicate that an IGBT in the inverter has failed. This circuit has a purpose similar, but not identical, to the "Iavg OL" circuit. However, the rail fault circuit protects against more catastrophic events, especially faults occurring within the inverter itself. It is a latched fault, requiring a reapplication of 'HV ON' to resume HV operation. DO NOT retry 'HV ON' more than once or twice after a rail fault occurs, since this indicates damage has occurred within the inverter and further attempts to turn on HV may worsen the damage.

R137 Slow OC Adjust: sets the trip point of the slow responding overload circuit, which monitors the output current. This circuit terminates HV if the load demands an excessive amount of average current. It is a latched fault, requiring a reapplication of 'HV ON' to resume HV operation. (This circuit is normally set to approximately 5% above the rated maximum load current). This circuit would function well during an excessive increase in load which might not be detected by the other protection circuitry.

R69 OV Adjust: sets the threshold of the overvoltage circuitry, which monitors the output voltage. This circuit terminates HV if it detects voltage higher than the set point. The set point is factory adjusted to 5% above the maximum rating of the supply.

R125 +10V Ref Adjust: calibrates the precision internal reference voltage to +10.000V.

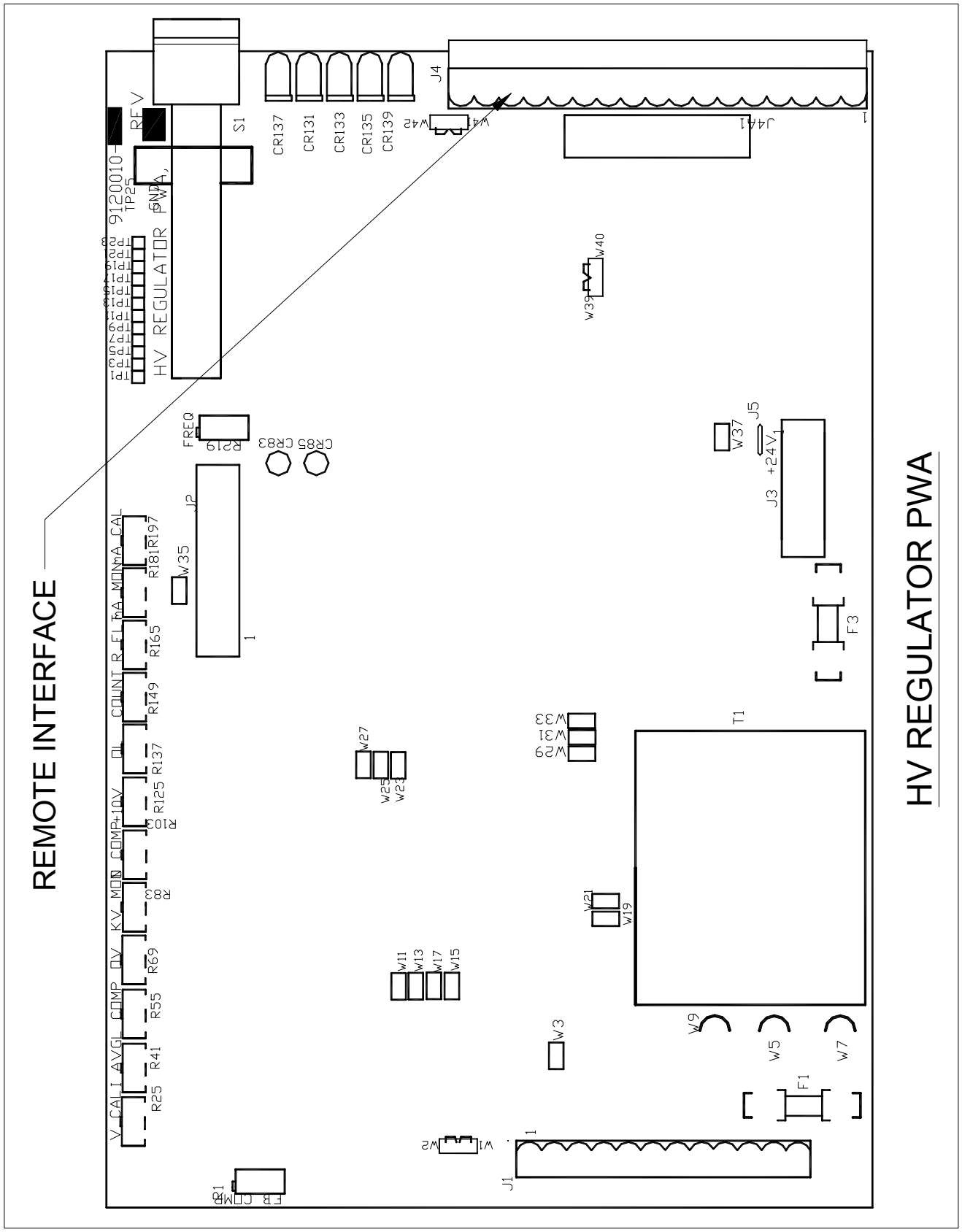


Figure 4 – Regulator Adjustment Potentiometers

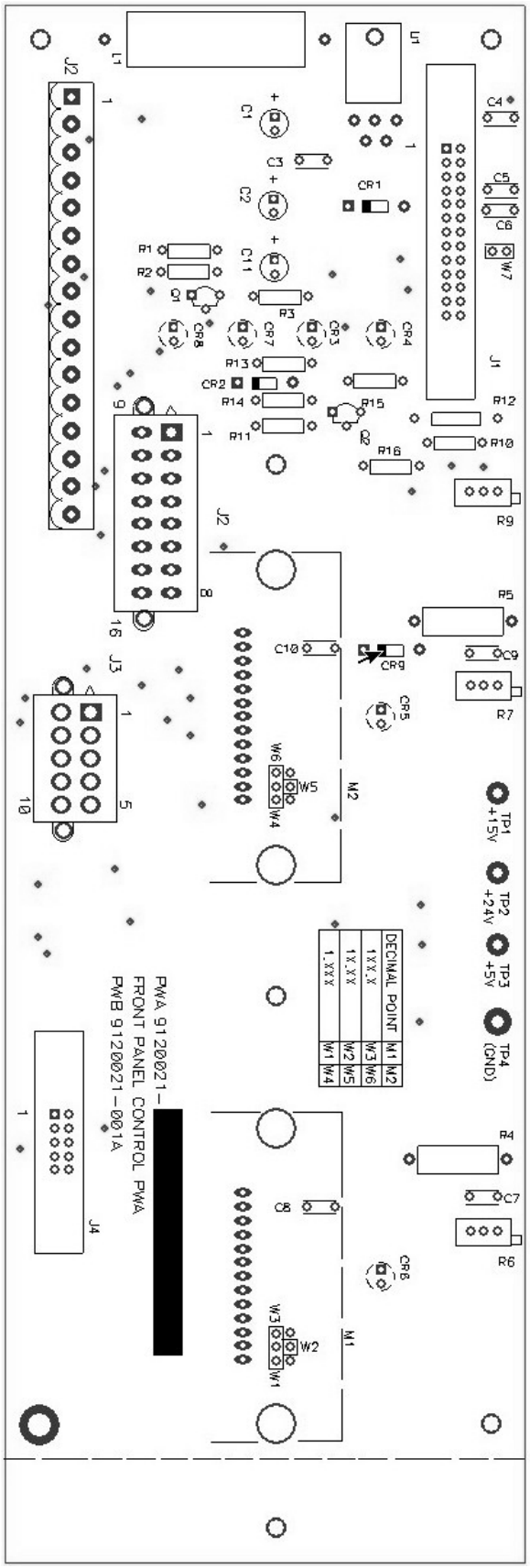


Figure 5 – Front Panel Adjustment Potentiometers

10. FAULTS / TROUBLESHOOTING

Faults

Overcurrent: If the output becomes shorted or if there is a surge in output current due to changes in the load that exceed the rated current, then this circuit will be tripped. Its threshold is set by R137. Once this circuit is tripped, HV is latched off. The power supply will give a fault indication by lighting the 'Fault' LED permanently. The 'HV ON' light will go out as well. This tells the user to correct the load and reactivate HV.

Both overload (or overcurrent) circuits are driven by a buffered current feedback signal that is derived from a shunt resistor located in the high voltage section of the power supply.

Overvoltage: Overvoltage is a fault which will rarely be tripped. Adjustable via R69, this circuit will be activated when it senses output voltage which is greater than the set point. An unstable system, due to load dynamics, may cause an overvoltage condition. This circuit is driven by a buffered voltage feedback signal derived from the HV divider. This fault will cause HV to be latched off and the Fault LED will light.

dV/dt: (Change in Voltage per Change in Time) The source of a fault of this type is an output arc, which causes a very large change in voltage in a short period of time. This circuit is also driven by the voltage feedback. Like the fast OL fault, this type of fault causes a rollback, which will not place the supply in a latched fault condition. It merely temporarily interrupts high voltage so the condition can clear. The output then recovers to the set point with little indication. The purpose for this type of recovery is that permanent shutdowns or faults can become a nuisance when arcing is a common occurrence in high voltage systems.

The dV/dt circuit is not adjustable.

AC Overload: The AC OL fault is the average primary current or "Avg OL" fault, which is more sensitive when the unit is operating closer to its rated output voltage and current. It is a slower responding circuit than the peak circuit and its main purpose is to limit power output by triggering rollbacks. Sensitivity is adjusted via R41.

The AC OL fault circuits are non-latching. They act to keep the primary current in the HV transformer from reaching excessive levels.

Rail Fault: This circuit protects against excessively large current in the power inverter, which may or may not be related to the primary current signal. However, the rail fault circuit is used to protect against more catastrophic events than the typical output conditions the primary current circuits were designed to withstand.

An imbalance in the voltage sharing of the power switches or a failed power switch might be the cause of a rail fault. Thus, you will rarely (if ever) see this type of latched fault. Like the other latched faults, this circuit will illuminate the Fault LED.

The sensitivity of this circuit is adjustable via R165.

Rollbacks and the One-Shot Timer

As discussed previously, a rollback is distinct from a latched fault in that it does not shut high voltage off permanently. A latched fault requires that an HV ON command be given again before HV can be reactivated.

The non-latched circuits cause a brief rollback (or limiting action). This is the case for the fast overload, dV/dt, peak primary current overload, and the average primary current overload circuits.

These circuits feed an additional circuit which controls the duration of time that the shutdown condition is permitted to be present. This circuit is called the rollback timer and its duration (called the rollback period) is adjustable via R9 on the front panel PCB. The rollback timer setting is one of the key ingredients to arc recovery performance and is critical in many applications.

The one-shot period must be long enough to allow an output arc to extinguish before the power supply begins to make output again. It should also allow sufficient time for the related electronics to be "reset" or return to their nominal state. On the other hand, it must not be too long as to cause operational difficulties.

Therefore, if problems are encountered which appear to be related to arc recovery, this potentiometer behind the front panel may be adjusted until the desired performance is achieved. To see the effect of this adjustment directly, it is helpful to use a storage oscilloscope to view the voltage monitor output on the rear panel (J4, pin 4) while rollbacks are occurring. You can induce a rollback by striking the output with a ground stick. As the rollback period is adjusted, you will see the off time of the power supply vary. The off time begins the instant a rollback event occurs and ends at the instant the output starts to rise again.

Troubleshooting

A. Equipment

Resistor Load:	13.5k ohms, 16.7kW
Current Sensor:	Tektronix Current Probe #P6021
Voltage Sensor:	Voltage Divider, 20kV minimum Ratio: 500:1 or greater Frequency Response: 100kHz minimum Resistance: 10 megohms typical Scope Probes: 10:1 and 100:1
Test Equipment:	Tektronix Oscilloscope, digital storage recommended Fluke Multimeter

B. Initial Turn-on

1.0 The 'Power ON' LED on the front panel board should be illuminated. If the front panel shows no lights, check the following:

1. Check for power on the input power line (208VAC, 3-phase).
2. Check the fuses on Regulator board 9120010 (see section 8.8 for fuse details).

2.0 It is normal for the front panel 'Fault' LED to blink momentarily when the circuit breaker is turned on. The 'Fault' LED should immediately go out, however if the light does not extinguish, check if any fault LEDs are illuminated on the rear panel. If one or more LED is illuminated, verify if the fault condition(s) is present and correct if possible.

3.0 High Voltage Ready Status

The green 'Ready' indicator in the 'HV ON' pushbutton should be illuminated when conditions are clear for HV on. If faults are present, this indicator will not illuminate.

C. Common Causes for Faults

1. Over-temperature (symptom: unit deactivates HV; ‘Ready’ indicator briefly off)
    a. Fan intake and/or outlet is blocked, preventing adequate airflow.
    b. Ambient air temperature exceeds specifications.
2. Interlock (symptom: unit deactivates HV; ‘Ready’ indicator off)
    a. Top cover interlock switch open.
    b. Interlock loop on J4 not shorted.
3. Over-voltage Fault
    a. Large inductive element connected to output.
    b. Misconnection of output to external high voltage source.
4. Overload Fault
    a. Effective load resistance too low; extreme dynamic load.
    b. Large capacitive load connected to output.
    c. HV output misconnected to ground.
5. dV/dt Fault (Arc Fault)
    a. Load arcing.
    b. Output connections with insufficient spacing for high voltages.
6. Rail Fault
    a. Failed IGBTs or HV rectifier diodes
    b. Large capacitive load connected to output.
    c. HV output misconnected to ground.

11. DRAWING LIST

System Schematic	(Schematic) D-6-7-1557
Power Inverter PWA	(Schematic) C-6-1895-39P
Front Panel PWA	(Schematic) D9120021-013
HV Regulator PWA	(Schematic) D9120010-011
High Voltage Module PWA	(Schematic) See System Schematic, D-6-7-1557
Output Low end PWA	(Schematic) B-6-1891-47AT

12. REPLACEMENT BILLS OF MATERIAL

Replacement bills of material are available on request.

13. FACTORY TEST PROCEDURE (ATP)

The Acceptance Test Procedure (ATP00255) is available on request.